IN THIS CHAPTER...)

INTEGRATING INTELLIGENT TRANSPORTATION SYSTEMS INTO REGIONAL TRANSPORTATION

One of the major advances in transportation during the past five years has been the application of advanced technologies in the operation of the transportation system. Known generically as "intelligent transportation systems" or ITS, these technology applications are becoming an increasingly important tool in the congestion reduction and mobility toolbox.

Many of the technologies strategies, and tools discussed elsewhere in this Toolbox, such as incident management, freeway management, traffic signal control and coordination, transit fleet management, traveler information systems electronic toll collection and the like, are elements of ITS. Local officials and transportation professional should thus view ITS as an important element of a strategic perspective on how to meet a region's multimodal transportation needs.

This chapter provides an overview of ITS as an important element of transportation planning and operational management, and discusses the major application areas where current experience indicates benefits can occur. Although each ITS application area will be ciscussed individually, the key message of this chapter is that these applications have a much more powerful impact when they are integrated and share information.

TOWARD A FOCUS ON SYSTEM OPERATIONS AND MANAGEMENT

A major theme of transportation policy over the next few years will be the importance of systems management and operational considerations in planning, project selection and program implementation. Due in part to financial constraints and negative environmental impacts, it is likely that many urban areas will be striving for a better balance between operational improvements and capacity-adding efforts. For example, in many areas, a forum does not exist for systems managers operators and safety personnel to discuss their programs and identify opportunities for joint activities. The existing transportation planning process and the technical committee structure of most metropolitan planning organizations could provide such a forum. ITS with its operational focus could be a stimulus for bringing these groups together. Some of the early deployments of ITS strategies were guided by broad-based stakeholder steering committees that adopted a regional vision for operational improvements while still participating as part of the regional transportation planning process In some cases the steering committees have continued to function as a part of the planning process providing input into the development of the long-range transportation plan, and

Local officials and transportation professionals should thus view ITS as an important element of a strategic perspective on how to meet a region's multimodal transportation needs.

recommending projects for incorporation into plans and programs.

As we become more concerned about enhanced efficiency of the existing transportation system, ITS will become an important focus for the planning process. As part of this on-going process, the general public and local officials can become educated as to the benefits of making operational improvements to the transportation system.

INTELLIGENT TRANSPORTATION SYSTEMS DEFINED

ITS defined: the application of advanced sensor; computer; electronics, and communications technologies and management strategies-in an integrated manner-to Increase the safety and efficiency of the surface transportation system.

The Intelligent Transportation Society of America (ITS America) defines intelligent transportation systems as "the application of advanced sensor, computer, electronics, and com*munications technologies and manage*ment strutegies-in *an* integrated man*ner-to increase the safey and efficiency* of the surface *transportation* system." The basic premise of ITS is that by integrating different system components and technologies in a consistent fashion, great benefits can occur.

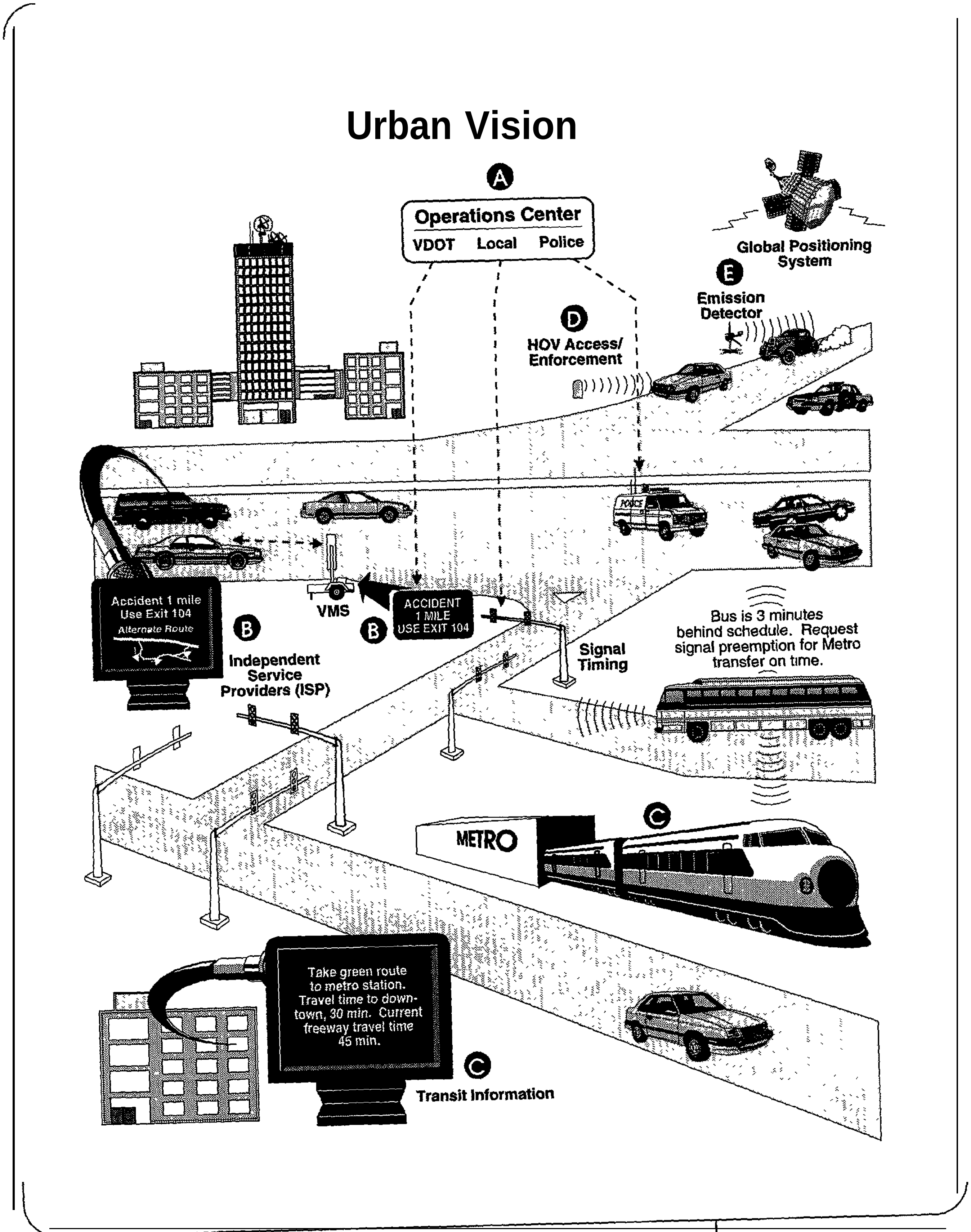
Previous chapters in this Toolbox have discussed ITS applications for both highway and transit operations, such as freeway and arterial management, interconnected traffic signals, areawide traveler information services, electronic toll collection, and transit automatic vehicle location. The key vision for ITS in this chapter is that such technologies will provide a core communications network, transportation system monitoring, and advanced information processing capabilities that can act as a foundation for the coordinated operation of the transportation system. As noted in a guidance manual on ITS planning (Smith 1996):

"Timely, accurate *information will* be readily available , *making* it possible to choose alternative modes, times and *routes* of travel. Electronic payment *capability will* improve the *convenience* of *transit,* parking *and* toll *facilities.* Communication *and coordination* among state and local traffic, *police,* emergency services, *and private towing companies will greatly reduce accident* and incident response and clearance time thus reducing delay, secondary accidents and *emissions* caused by stop and go *traffic."*

Figure 6-1 shows how this vision of ITS could be applied in an urban setting. Specific elements of this vision, as noted in (Smith 1996) include:

- Real-time monitoring equipment will be in place on Interstates and arterials and on freight "probe" vehicles in urban areas, feeding data to the transportation operations center where software will automatically identify problems in the network. When a problem is detected, personnel from the state DOT, local agencies, and police will work together at the center to provide an immediate, coordinated response. In addition, arterial signal timings will automatically adjust to changes in traffic demand caused by incidents to provide maximum efficiency of flow throughout the region, and to allow adaptive signal timing for transit vehicles.
- Real-time information will be provided to motorists by the state and local transportation agencies and

Figure 6.1: A Vision For Urban ITS Applications



Source smith 1996

One of **the** *key characteristics of the development of ITS technologies and their application to the transportation system has been a conscientious effort to adopt a customer orientation in their design.*

the private sector through the use of highway advisory radio, variable message signs and the Highway Helpline, and by Independent Service Providers (ISPs) providing personalized information through in-vehicle devices, dial-up services, personal digital assistants, the Internet, and television and radio stations.

- Transit ridership will be further enhanced with the use of automatic vehicle location devices that will allow dispatchers to know the location of any bus at any point in time. By combining bus location information with the real-time traffic condition information, routes will be monitored and adjusted when necessary to ensure schedule adherence.

- Real-time schedule information will be available to the public to allow for informed mode-choice decisions.

- Automatic vehicle identification (AVI) technology will be used on HOV facilities to aid in access control and enforcement. HOV vehicles such as vanpools and established carpools will be equipped with transponders that are read as they enter the HOV facility.

- Vehicle emissions will be monitored electronically on the highway to identify those vehicles which violate pollution standards. This will reduce the number of vehicles that are required to report to emissions monitoring stations.

- Automatic toll payment/collection will allow vehicles to use toll facilities without stopping, and will provide for the possibility of differential pricing on toll facilities by time of day or level of congestion.

- System performance and other vital planning dam can be collected at little or substantially reduced cost.

Table 6.1 shows the relation&p between typical transportation problems that are faced by urban areas, the conventional means of addressing these problems, and the tools found in an operational or systems approach. As can be seen in this Table, many of the tools discussed previously in this Toolbox can be part of the advanced systems approach.

One of the key characteristics of the development of ITS technologies and their application to the transportation system has been a conscientious effort to adopt a customer orientation in their design. The fundamental concept in this implementation approach is to understand the needs of those who will use the technologies (or the products that are produced), and to orient the implementation to satisfy these needs. This approach has important implications on the types of strategies that should be used to implement ITS actions. More will be said about this later.

Table 6.1: Relationship Between Problems, Solutions, and ITS *Source: JHK & Assocs. 1996*

Problem	Solution	Conventional Approach	Advanced Systems Approach	Supporting Market Packages	Considerations
Traffic Congestion	Increase roadway capacity	New roads New lanes	Advanced traffic control Incident management Electronic toll collection Corridor management Advanced vehicle systems	Surface street control Freeway control Incident management system Dynamic toll/parking fee management Regional traffic control Advanced vehicle longitudinal control Automated highways	**Conventional** Environmental constraints Land use and community resistance High cost of construction **Advanced** Near term services yield modest benefits Latent demand effects
	Increase passenger throughput	HOV lanes Carpooling Fixed route transit	Real-time ride matching Integrate transit and feeder services Flexible route transit New personalized transit	Dynamic ridesharing Multimodal coordination Demand responsive transit operations	Privacy and personal security
	Reduce demand	Flextime programs	Telecommuting Other telesubstitutions Transportation pricing	Dynamic toll/parking fee management	Significant component of demand relatively inelastic
Lack of Mobility and Accessibility	Provide user friendly access	Expand fixed route transit Radio and TV traffic reports	Multimodal pre-trip and en-route traveler info. Respond dynamically to changing demand Personalized transit services Common, enhanced fare card	Interactive traveler information Demand responsive transit operations Transit passenger and fare management	**Conventional** Declining ridership **Advanced** Interjurisdictional cooperation Standards
Disconnected Transportation Modes	Improve intermodality	Interagency agreements	Regional transportation management systems Regional transportation info clearinghouse Disseminate multimode information pre-trip and en-route	Regional traffic control Multimodal coordination Interactive traveler information	**Conventional** Often static and/or slow to adapt as needs change **Advanced** Existing system incompatibilities Standards

Table 6.1: Continued

Problem	Solution	Conventional Approach	Advanced Systems Approach	Supporting Market Packages	Considerations
Severe Budgetary Constraints	Use existing funding Leverage new funding sources	Existing funding authorizations	Privatize market packages Public/private partnerships Barter right-of-way Advanced maintenance strategies Increased emphasis on fees	Transit maintenance	Market uncertainties make private sector cautious Telecommunications deregulation makes ROW barter a near term opportunity Equity
Transportation Following Emergencies	Improve disaster response plans	Review and approve existing emergency plans	Establish emergency response center (ERC) Internetwork ERC w/ law enforcement, emergency units, traffic management,etc	Emergency response Incident management system Emergency routing	**Conventional** Coordination challenges **Advanced** Coordination challenges Standards
Traffic Accidents, Injuries, and Fatalities	Improve safety	Improve road geometry Improve sight distance Traffic signals Fewer at-grade crossings Sobriety check Lights Speed limits	Partially and fully automated vehicle control systems Intersection collision avoidance Warning systems Vehicle condition checks Driver condition monitoring Driver vision enhancement Detection of road conditions Automated warning	All safety market packages Intersection collision avoidance In-vehicle signing Vehicle safety monitoring Driver safety monitoring Driver visibility improvement Network surveillance Traffic information dissemination In -vehicle signing Mayday support	**Conventional** High costs Human error is primary cause **Advanced** Mixed results for initial collision warning devices Relatively slow roll out for safety packages anticipated
Air Pollution	Increase trans system efficiency, reduce travel	More efficient conventional vehicles Vehicle emissions inspections Promotion of alts. to SOV Increase cap. to reduce vehicle delay Regulations	Remote sensing of emissions Advanced traffic management to smooth flows Multimodal pre-trip info Telecommuting Other telesubstitutions Transportation pricing Alternative fuel vehicles	Emissions and hazards sensing Surface street control Freeway control Regional traffic control Interactive traveler information Dynamic toll/parking fee	**Conventional** Increasing demand can offset initial benefit of added capacity Regulations, inspections are unpopular and onerous **Advanced** Increasing demand can offset efficiency improvements

Nine key ITS infrastructure components have been identified as being essential to traffic management and traveler information services within a metropolitan area. They are:

- Regional Multimodal Traveler Information System
- Traffic Signal Control Systems
- Freeway Management Systems
- Transit Management Systems
- Incident Management Programs
- Electronic Toll Collection System
- Electronic Fare Payment System
- Railroad Grade Crossing Warning System
- Emergency Management System

Each of these components will be discussed in turn below.

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Regional Multimodal Traveler Information Systems (RMTIS)

Description: Providing information to travelers is an inherent component of ITS strategies. Thus, it is often difficult to separate RMTIS from other ITS applications such as Freeway Management Systems or Incident Management Programs. RMTIS provides new ways to distribute expanded information to travelers for both "pre-trip" and "en-route" elements of trip-making. The more advanced applications provide multimodal information for all system services so that travelers can make informed decisions on mode and route choice, or even whether the trip should be made. RMTIS is one area of ITS where private companies have shown interest in marketing the resulting product, i.e., traveler information.

Some examples of projects that illustrate RMTIS applications are: (U. S. DOT 1996)

DIRECT, Detroit, MI-The Michigan DOT along with many partners is deploying Driver Information Radio Experimenting with Communication Technology (DIRECT) to communicate with motorists. Methods include radio data system (RDS), FM radio, highway advisory radio, and cellular phones. A traffic center will monitor roadway performance and provide traffic advisory updates via these media.

Travlnfo, San Francisco-This $7 million comprehensive, region-wide traveler information system will provide multi-modal transportation information via a variety of sources. The design of this system will be "open access" to allow for future enhancements and transfer of technology.

RMTIS include such things as:

- Broadcast traveler information
- Interactive traveler information
- Autonomous route guidance
- Dynamic route guidance
- Variable message signs
- Yellow pages and reservations
- Dynamic ridesharing
- In-vehicle informatron
- Integrated transportation
- Kiosks
- Transportation management centers
- Integrated transportation management/route guidance

TravLink, Minneapolis-TravLink is a combined freeway and transit information system in the I-394 corridor west of downtown Minneapolis. Real-time transit and traffic information is provided to travelers via kiosks and terminals at employment sites, home, shopping centers, and transit stations.

Los Angeles Smart Traveler-A small number of information kiosks were deployed in office lobbies and shopping plazas. The number of information requests ranged from 20 to 100 in a 20-hour day, with over half the requests including a desire for transit information, and 83 percent requesting a freeway map.

The transportation benefits of RMTIS applications relate primarily to improved network efficiencies from travelers seeking optimal routes and enhanced use of ***alternative*** *modes*

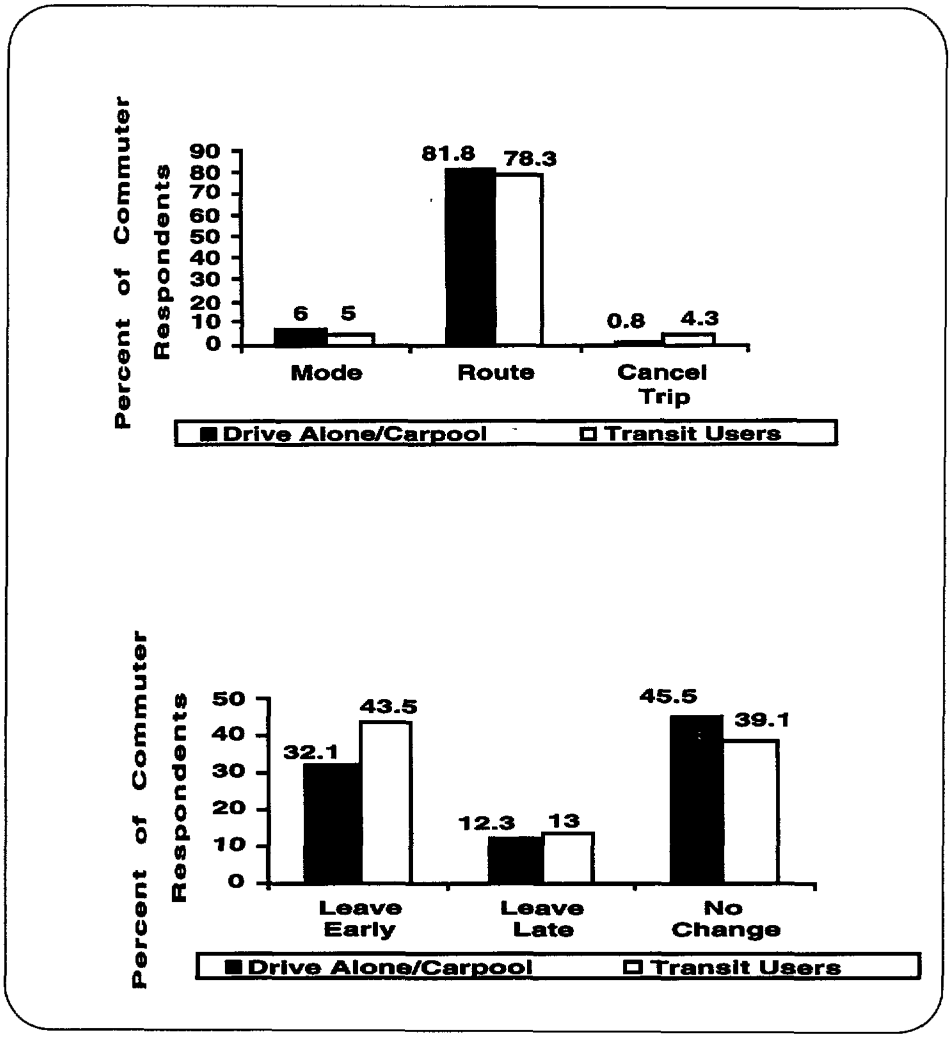
Smart Route in Boston-RealTime traffic and transit information is provided over computerized telephone information services. Alpha numeric pagers are used to transmit up-to-the-minute traffic information to subscribers approximately 30 times per day.

Atlanta Olympics Showcase- Traveler information was provided to those visiting the 1996 Olympics via information kiosks, wireless computers, interactive television in hotels, a dedicated transportation channel on cable television, in-vehicle navigation devices, and on-line computer services. This application was the first of its kind for the variety of information provided and the numerous media used.

Benefits/Costs: The transportation benefits of RMTIS applications relate primarily to improved network efficiencies from travelers seeking optimal (i.e., minimum time) routes and enhanced use of alternative (to the single occupant automobile) modes. An illustration of the impact of travel information on travel behavior is shown in Figure 6-2. These results came from a survey of commuters in San Francisco who were asked how the travel information they received affected their trip behavior (Federal Highway Administration 1995a). As can be seen, route deviation was the most often mentioned change. It is interesting to note that 52 percent of those receiving travel information actually changed some characteristic of their trip [a much higher proportion of non-commuters (72 percent) undertook such a change compared to commuters (54 percent)]

A simulation of an urban area with a 5 percent assumed RMTIS capability in automobiles estimated that for congested conditions these automobiles experienced an 8 to 16 percent reduction in travel time due to diversions. Without congestion, the impact of RMTIS on network travel time was negligible (Federal Transit Administration 1996). By reducing travel times in the network, the long term impact might very well be to encourage continued use of the single occupant automobile. This impact could lead to increased vehicle miles traveled and thus negatively affect air quality (assuming no immediate improvements in vehicle fleet emissions characteristics). RMTIS is thus one of the ITS application areas where impacts should be viewed from both the short- and long-term perspective.

Figure 6.2: Mode Choice, Route and Departure Time Changes Based on Traffic Information (Combined Pre-Trip and En-Route)



Source: FHWA 1995a

Some RMTIS projects that illustrate impacts include the following:

New Jersey Transit's Automated Telephone Information System—New Jersey Transit implemented an automated telephone information system that dramatically reduced the waiting time for customers. The total number of calls increased in one year from 30,000 to 40,000. The average waiting time was cut from 85 to 27 seconds, and the lost call rate (i.e., number of people who hung up) fell from 10 percent to 3 percent.

TravLink—As part of the TravLink implementation, videotext terminals were distributed to over 300 users and 10 businesses. An evaluation of the terminal usage showed that over 90 participants logged on one to five times; 17 logged on 6 to 10 times; and nine logged on 11 to 15 times. The majority of menu selections were for bus arrival times at stops. The initial 150 users recruited for the program logged in over 1,300 times in the first month.

TravTek, Orlando-Use of in-vehicle navigational aids in rental vehicles showed that enhanced driver information resulted in a 19 percent reduction in travel time on properly followed routes, a 20 percent reduction in travel time if turns were missed (i.e., recovery time for TravTek vehicles compared to non-TravTek vehicles), and a decrease in probability of missing a given turn from 5.4 percent to 3.6 percent.

Seattle and Boston RMTIS Surveys- Surveys in Seattle and Boston indicate that when provided with better traveler information, travelers will split evenly between changing time of travel and route followed, with 5 to 10 percent changing travel mode.

One of the more extensive evaluations of Rh4TIS actions occurred during the 1996 Olympic Games in Atlanta. The RMTIS strategy included hotel interactive cable channel information, Internet access, personal communication devices, and in-vehicle traveler information devices. Figure 6-3 shows the impact of these different technologies on the travel plans or decisions of those using them.

Other RMTIS projects are described in Chapter 2. In addition, References (Federal Highway Administration 199513; Intelligent Transportation Society of America 1996; and Congressional Budget Office 1995) provide descriptions of such projects. Table 6.2 shows the benefits associated with RMTIS actions.

Implementation: Given the perspective of implementing RMTIS actions within the context of a regional ITS strategy, the implementation characteristics of all ITS actions are discussed on page 292 in the section entitled, "Implementation of a Regional ITS Strategy."

Figure 6.3: Travelers Making Travel Changes After Using Showcase Technologies

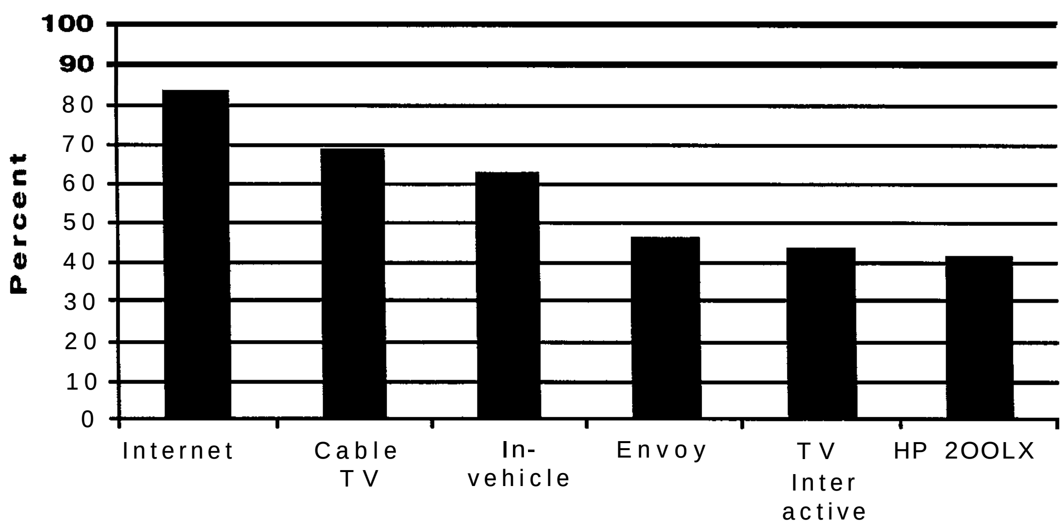


Table 6.2: Benefits from RMTIS Applications

Market Package	Likely Benefits	Context Where Benefits May Accrue
Broadcast Based ATIS	Possible benefits as high as other Interactlve RMTIS services depending on capability of m-vehicle devices	Primary value for Incident-related traffic delays Higher benefits to travelers with long trips multiple modes and route alts.
Interactive Traveler Information	Reduces travel time Increases speeds/decreases stops Some benefits for non-equipped travelers Higher benefits for pre-trip vs en-route Information Decreasing benefits vvlth higher market penetration	Primary value for incident-related traffic delays Higher benefits to travelers with long trips, multiple mode and route alts Decreasing benefits with higher network loadings (i.e., , higher congestion)
Guidance Type Autonomous Route Dynamic Route ISP-Based Route integrated Transportation Management	Reduces travel time Increases speeds/decreases stops Some benefits for non-equipped travelers Higher benefits for pre-trip vs en-route information Decreasing benefits with higher market penetration	Primary value for Incident-related traffic delays Higher benefits to travelers with longer trips. multiple mode and route alts Higher benefits for visitors and other unfamiliar travelers
Yellow Pages and Reservation	Potential reduction of VMT	Benefits highest for visitors Familiar travelers benefit from parking reservation
Dynamic Rideshare	Increased vehicle occupancy Improved individual mobility	significant density of related tnps is necessary to ensure ride match
In-Vehicle Signing	Reduces in-search time Reduces accidents	Anticipated benefits in congested areas, night driving and rural areas Aid to visually challenged drivers

Source FHWA 1996 .

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Traffic Signal Control Systems include such things as:

- Network surveillance
- Regional traffic control
- System communications
- Traffic management centers
- Surface street control
- Interconnected signals
- Traffic sensors
- Real-time monitoring and control

Traffic Signal Control Systems (TSCS)

Description: One of the most cost effective strategies for reducing congestion is to provide interconnected or real-time control of traffic signals. In the context of ITS, this usually means some form of monitoring of traffic flows and a computerized central coordinating function for signal control. The elements of a TSCS include at a minimum a central office with computer capabilities, a communications network, and local signal coordinators. Such a system can be linked to video surveillance, incident detection/management, and traveler information systems in the context of an overall transportation management system.

There are three major types of signal control that are used in practice (Dudek and Ullman 1992). Open network control refers to the coordination of a series of signals along an arterial street. The primary emphasis is on developing a "progression" so that vehicles starting at one end can travel along the arterial without stopping. Closed network control refers to coordinating a group of traffic signals along two or more arterials that intersect. Coordination may occur among all signals in the network or control may be provided for individual groupings of signals. Areawide system control refers to the surveillance and control of a large portion of the traffic signals in an urban area.

Some examples of traffic signal control systems include: (U.S. DOT 1995)

FAST-TRAC, Oakland County, Michigan-Traffic adaptive control systems will allow real time traffic detection and control. Vehicles equipped with route guidance and driver information systems will receive system performance information from a traffic operations center that will integrate the data collection and information dissemination activities. FAST-TRAC started in 1992 and is now in 11 communities, serving over 300 intersections (the goal is to serve 1,000 intersections). The results of this project include an 89 percent decrease in left-turn accidents at dangerous intersections, a 27 percent decrease in total traffic-related injuries and a 19 percent increase in vehicle speeds. In addition, signals can be adjusted to accommodate one-way rush hour traffic patterns and to manage traffic for major public events and activities, thus reducing overall delay.

Centralized Traffic Signal Control, Abilene, Texas-Coordinated traffic signals using a computerized system and under centralized control provided a 37 percent reduction in delays, a 22 percent increase in travel speed, a 14 percent reduction in travel time, and a 12 percent reduction in carbon monoxide emissions.

Sacramento Coordinated Signal Project-The City of Sacramento has undertaken an extensive traffic signal upgrade program that includes improving 220 intersections located primarily within the downtown area. This upgrade has resulted in overall travel speed improvements of 10 percent.

Colorado Springs Traffic Management-Colorado Springs implemented a comprehensive traffic management system over a four-year period that included instituting a traffic control system that manages 265 intersections (with a theoretical capacity of controlling over 8,000 intersections). The signal controllers have built into them an automatic pager that summons maintenance personnel when failure occurs.

Metro-Dade Traffic Control System-The Metro-Dade Traffic Control System of Miami is one of the oldest computerized traffic signal control systems in the United States. More than 2,000 intersections are under system control. The system monitors traffic flows and adjusts signal control strategies accordingly. For example, signal timings are adjusted for special events such as parades and sporting events. Control of signals near schools are modified to increase pedestrian safety. An evaluation of this system showed that the number of stops decreases by 41 percent; average speeds increased by 25 percent; travel time decreased by 20 percent; fuel consumption decreased by 15 percent; other vehicle operating costs decreased by 14 percent; pollutant emissions decreased by 20 percent; and signal repair response time decreased by 20 percent (Dade county 1990).

INFORM-The Information for Motorists (INFORM) program on Long Island, New York was one of the first corridor-wide strategies to manage freeways and adjacent arterials. The arterial street traffic signal component of the INFORM system controls about 120 traffic signals with centralized computer control. On one route in the corridor, average travel times have been reduced from 43 minutes to 30 minutes-a 30 percent reduction.

Los Angeles ATSAC-Los Angeles initiated the first phase of its automated traffic surveillance and control (ATSAC) system in 1984, just prior to the 1984 Summer Olympic Games. From this initial system which included 118 intersections and 396 detectors, the system is expected to reach 4,000 signals under control by 1998 (Rowe 1991). An evaluation of this system has estimated a reduction of 35 percent in stops; 20 percent less delay; a 13 percent reduction in travel time; a 12.5 percent reduction in fuel consumption; and a 10 percent reduction in pollutant emissions. An overall economic analysis estimated a benefit/cost ratio of 9.8 to 1.

One of the most cost effective strategies for reducing congestion is to provide interconnected or real-time control of traffic signals.

Benefits/Costs and Implementation: The benefits and costs of traffic signal control systems are discussed in Chapter 2. This discussion will not be repeated here. Given the perspective of implementing signal control systems within the context of a regional ITS strategy, the implementation characteristics are discussed on page 292 in the section entitled, "Implementation of a Regional ITS Strategy."

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FMS includes such things as:

- Network surveillance
- Regional traffic control
- Probe surveillance
- Incident management system
- Surface street control
- Emasrons/hazards sensing
- Freeway control
- Virtual traffic management center and smart probes management
- HOV and reversible lane
- Network performance evaluation
- Traffic information dissemination
- Dynamic toll/parking fee management
- Freeway control

Freeway Management Systems (FMS)

Description: The goal of freeway management systems (FMS) is to provide "real-time" control capability of the transportation system that adapts to traffic movement, anticipating when and where traffic will be moving, so that control systems and strategies (e.g., ramp metering systems) can be used to provide optimal service (U.S. DOT 1996). This ITS application area thus depends on coordinated communications systems, sensors to monitor system performance, and analysis and control strategies to coordinate system response.

Some examples of projects that illustrate FMS applications include:

Montgomery County (Maryland) Advanced Traffic Management System-Automatic vehicle location devices will be placed on the county's bus fleet, and when combined with two-way communications, real-time graphics, priority information dissemination, and monitoring/ control software, will provide system-wide transportation management capability.

San Antonio TransGuide-A 190-mile/306 km FMS is proposed for San Antonio consisting of a central traffic control center, complete digital communications, changeable message signs, lane control signals, surveillance cameras, and loop detectors. The system goal is an under-two-minute incident detection time and an under-one-minute system response time. Phase 1 of this system (26 miles/42 kms) has been implemented on the freeways near downtown.

SMART Corridor, Los Angeles-The Santa Monica freeway corridor will be managed by advising travelers of current conditions and alternate routes through highway advisory radio, changeable message signs, kiosks, and teletext capabilities. The objectives of this corridor project are to reduce accidents, provide congestion relief, improve emergency response, and assure inter-agency traffic management coordination.

Benefits/Costs: The transportation benefits of FMS actions relate primarily to reduced congestion and accident rates (Dudek and Ullman 1992). Deployment of these types of market packages at a regional level could have significant impact on travel in the network, whereas local implementation (i.e., in a corridor or at specific intersections) will provide benefits on a more limited scale. The impacts of these actions must also be viewed from the perspective of both short and long-term consequences. Table 6.3 shows the results of a qualitative air quality assessment of ITS actions over both time frames (Jack Faucett & Assocs. 1993). The difference that improvements in mobility and accessibility over the long-term could influence urban development and travel patterns, and thus the long-term consequences of these actions. The air quality assessment shown in Table 6.3 reflects not only these longer terra changes, but also the evolutionary direction of motor vehicle emissions-emitting factors. For example, recent research on vehicle emissions suggests that a large number of accelerations and decelerations cause high levels of emissions. Traffic management steps that reduce these types of vehicle activities will have. a beneficial impact on emissions level. However, making vehicle use easier and more convenient will also continue the trend toward heavy reliance on single occupant vehicles resulting in continued growth in vehicle miles traveled.

The list of FMS components also includes those technologies that enable real-time electronic toll collection, and thus the implementation of congestion pricing. As shown in Table 6.3, and discussed in Chapter 5, congestion pricing is probably the most effective means of affecting travel behavior and encouraging mode shifts. Thus, the FMS component of an integrated ITS regional strategy could play a critical role in helping a region meet its transportation and environmental goals.

The following projects illustrate the types of benefits that can be associated with FMS implementation. Note that these impacts are primarily short-term in nature and do not include longer term travel behavior shifts discussed above.

INFORM Program, Long Island, NY-Coordinated traffic management on parallel expressways, ramp metering, and arterial coordination has resulted in an estimated delay savings of 1900 vehicle-hours per peak period incident and 300,000 vehicle-hours in incident-related delay annually. Freeway speeds increased 13 percent.

Smart Reversible Lanes, Dallas-Reversible lanes on two major Dallas arterials are managed remotely from a traffic operation center that controls overhead electronic signs to alert motorist to lane switching. By so doing, Dallas was able to increase the capacity of both arterials by 33 percent. This system cost $1.2 million.

Minneapolis/St. Paul-A comprehensive ramp metering/traffic management system in the Twin Cities increased speeds from 34 mph to 46 mph; accident rates dropped 27 percent, and annual accident rates dropped from 3.4 per million vehicle miles to 2.11 per million vehicle miles. The Helper Program for dealing with freeway incidents has reduced the duration of a stall to 8 minutes with an annual benefit of reduced delays of $1.4 million.

The goal of freeway management systems (FMS) is to provide "real-time" control capability of the transportation system that adapts to traffic movement, anticipating when and where traffic will be moving so that control systems and strategies can be used to provide optimal service.

Recent research on vehicle emissions suggests that a large number of accelerations and decelerations cause high levels of emissions Traffic management steps that reduce these types of vehicle activities will have a beneficial impact on emissions levels.

Table 6.3: Air Quality Impacts of ITS Actions

Long Term Regional Impacts

Action Bundle	Congestion	Tripmaking	Trip Distance	Mode Shifts	Air Quality
Traffic/Incident Management	Large	Moderate	Insignificant	Small	Small
Route Guidance	Moderate	Moderate	Small	Insignificant	Small
Accident Reduction	Small	Insignificant	Insignificant	Small	Insignificant
Vehicle Control/ Monitoring	Large	Large	Large	Moderate	Large
Commercial Vehicle Inspect.	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Trip Guidance and Public Transit	Large	Moderate	Small	Moderate	Moderate
Enabling Tech. for Pricing	Large	Large	Large	Large	Large
Remote Sensing	Insignificant	Insignificant	Insignificant	Insignificant	Large

Short-Term Regional Impacts

Action Bundle	Congestion	Tripmaking	Trip Distance	Mode Shifts	Air Quality
Traffic/Incident Management	Large	Moderate	Insignificant	Insignificant	Small
Route Guidance	Small	Small	Small	Insignificant	Small
Accident Reduction	Small	Insignificant	Insignificant	Insignificant	Small
Vehicle Control/ Monitoring	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Commercial Vehicle Inspect	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Trip Guidance and Public Transit	Large	Moderate	Insignificant	Large	Large
Enabling Tech. for Pricing	Moderate	Moderate	Moderate	Moderate	Moderate
Remote Sensing	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant

Source Jack Faucett & Assocs 1993

Table 6.3: Continued

Long Term Corridor Impacts

Action Bundle	Congestion	Tripmaking	Trip Distance	Mode Shifts	Air Quality
Traffic/Incident Management	Large	Moderate	Moderate	Small	Small
Route Guidance	Large	Moderate	Insignificant	Insignificant	Small
Accident Reduction	Moderate	Insignificant	Insignificant	Insignificant	Moderate
Vehicle Control/ Monitoring	Large	Large	Large	Moderate	Large
Commercial Vehicle Inspect	Small	Insignificant	Insignificant	Insignificant	Small
Trip Guidance and Public Transit	Large	Moderate	Moderate	Large	Large
Enabling Tech for Pricing	Large	Large	Large	Large	Large
Remote Sensing	Insignificant	Insignificant	Insignificant	Insignificant	Large

Short-Term Corridor Impact

Action Bundle	Congestion	Tripmaking	Trip Distance	Mode Shifts	Air Quality
Traffic/Incident Management	Moderate	Small	Insignificant	Insignificant	Small
Route Guidance	Small	Insignificant	Small	Insignificant	Insignificant
Accident Reduction	Small	Insignificant	Insignificant	Insignificant	Small
Vehicle Control/ Monitoring	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Commercial Vehicle Inspect.	Small	Insignificant	Insignificant	Insignificant	Small
Trip Guidance and Public Transit	Moderate	Moderate	Insignificant	Large	Moderate
Enabling Tech for Pricing	Large	Large	Large	Moderate	Large
Remote Sensing	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant

Source Jack Faucett & Assoc. 1993

Chicago's Traffic Surveillance and Control System-Beginning in 1961 with emergency traffic patrols, Chicago's freeway management system has grown to include surveillance at 1/3 mile intervals, ramp controls at 95 locations, 12 variable message signs, highway advisory radio at 7 locations, a central control center, and cellular telephone communications. One evaluation of this system estimates that it has reduced peak-period traffic congestion by 60 percent and has reduced accidents by 18 percent (Judycki and Robinson 1990).

Detroit's SCANDI System-Initiated in 1982, Detroit's Surveillance Control and Driver Information system has five major components-surveillance at all ramps and at 1/3 mile spacing on the freeway, closed circuit television at high accident locations, variable message signs, ramp metering at 51 locations, and motorist aid telephones placed at 69 locations along the freeway system. A study of this system estimated that ramp metering increased speeds on the freeway by 8 percent, accidents were reduced by 50 percent, and injury accidents were reduced by 71 percent. (Kostyniuk et al 1988).

One of the more comprehensive evaluations of an FMS program was the TransGuide system in San Antonio described above (Henk Molina, and Irwin 1997). This FMS included 26 miles/42 kms of complete digital communications network with field equipment consisting of changeable message signs, lane control signals, loop detectors, and surveillance cameras, all under the control of a central operations center. The before and after data for system operation indicated a 15 percent reduction in overall accident rates and a 21 percent reduction in projected accident rates (accident rates based on experimental control freeway segments not under TransGuide guidance). In addition, there was approximately a 20 percent reduction in incident response time compared to pre-TransGuide implementation. A simulation of a major incident indicated that such delay savings amounted to 700 vehicle-hours and 2,600 gallons of fuel for that incident.

A recent study of an FMS system in Toronto showed that the system resulted in a substantial decrease in accidents-an 18 to 25 percent reduction in rear-end collisions and a 1 to 8 percent reduction in other accidents (Bhagwant, Mucsi, and Ugge 1996).

Other FMS projects have been described elsewhere in this Toolbox. In each case, the level of benefit relates to the scale of application and the targeted user group. Table 6.4 shows the type of benefits that can be expected from FMS applications.

With regard to costs, FMS applications can cost relatively little ($800,000 to $900,000) or they can be expensive ($50 to $70 million). The expense clearly reflects the scale of application. For example, the Oakland County FAST-TRAC project is estimated to cost $70 million whereas the San Antonio TransGuide project is estimated to cost $1.3 million.

Table 6.4: Benefits From FMS Applications

Applications	Likely Benefits	Context Where Benefits May Accrue
Network Surveillance	Indirect benefits only Data support for other FMS services	Essential component for incident detection and sometimes for signal control Higher value for regions where traffic patterns are transient and unpredictable
Surface Street Control	Reduction in travel time Reduction in queue time Reduction in stops Increase in speeds Reduction in fuel consumption Reductions in emissions Reduction in intersection-related accident rates with higher reductions possible for left-turn accidents Significant benefit/cost ratio	Most surface street systems will benefit from this application Cities with major traffic generators such as theme parks or stadiums will benefit more It is expected that signal coordination tailored to specific local traffic patterns can have significantly higher benefits
Probe Surveillance	Indirect benefits only Data support for other FMS services	Essential component for accident detection and sometimes for signal control Higher value for regions where traffic patterns are transient and unpredictable
Freeway Control	Increase in freeway speed during congested peak hours, depending on level of congestion Increase in freeway throughput Reduction in travel time Reduction in queue time Reduction in fuel consumption Reduction in emissions	
Regional Traffic Control	Uncertain level of benefits, but can be significant in many cases	High benefits in region with many cities or jurisdictions
HOV and Reversible Lane Management	Largely unknown level of benefits	Regions that respond by substantial shifts from SOVs to HOVs
Incident Management System	Reduction in incident response times for large urban areas Safety patrols report significant reductions in incident-related vehicle hours of delay Significant benefits to cost ratio	Regions with high frequency of incidents Regions where incident delays constitute a substantial part of delays
Traffic Information Dissemination	Positive value but quantitative estimates have yet to be determined	Regions where travelers respond to traffic information by either changing departure time, route choice, etc Regions that have alternate routes, mode choices, etc.
Traffic Network Performance Evaluation	Reductions in data collection cost Benefits depend heavily on current surveillance and analysis activities	Regions that have TDM programs Regions that have traffic management plans responding to performance evaluation
Dynamic Toll/ Parking Fee Management	Reduce peak hour congestion Reduction in toll plaza operating costs Reduced incidents and emissions	
Emissions and Environmental Hazards Sensing	Reduced incident rate Improve air quality	High value in geographic areas in air quality non-attainment
Virtual TMC and Smart Probe		Assumed value in rural and inter-urban areas with low investment opportunity

Source FHWA 1996

A more extensive list of FMS project descriptions and impacts can be found in (Intelligent Transportation Society of America 1996; Federal Highway Administration 1995; U. S. DOT 1996; Congressional Budget Office 1995).

Implementation: Given the perspective of implementing FMS actions within the context of a regional ITS strategy, the implementation characteristics of all the ITS actions are discussed on page 292 in the section entitled, "Implementation of a Regional ITS Strategy."

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Transit Management Systems (TMS)

Description: Transit management systems (TMS) include the use of advanced navigation, information, and communication technologies to improve the operations of public transportation systems. These TMS enhancements to operations have occurred primarily in fleet management, mobility management, traveler information, and electronic fare payment.

The type of objectives that TMS actions can help achieve include: (Horan and Baker 1993).

Enhance the Quality of On-the-Street Service to Customers

- Increase the convenience of fare payments within and between modes
- Improve safety and security
- Increase service reliability
- Minimize passenger travel times
- Enhance opportunities for customer feedback

Improve System Productivity and Job Satisfaction

- Improve schedule adherence and incident response
- Improve timeliness and accuracy of operating data for service planning/scheduling
- Improve speed of identification and response to vehicle and facility failures
- Provide integrated information management systems
- Reduce worker stress and increase job satisfaction

Enhance the Contribution of Public Transportation Systems to *Overall* Community Goals

- Facilitate the ability to provide discounted fares to special user groups
- Improve communications with users having disabilities
- Improve the mobility of users with ambulatory disabilities
- Increase the extent, scope, and effectiveness of TDM programs
- Increase the utilization of high occupancy vehicles

Expand the Knowledge Base of Professionals *Concerned with* TMS Innovations

- Conduct thorough evaluations of operational tests
- Develop an effective information dissemination process
- Showcase successful TMS innovations in model operation tests

Some examples of projects that illustrate TMS applications include: (Federal Transit Administration 1996).

TMS includes such things as:

- Pre-trip, enroute traveler information
- Real time ridesharrng
- Transit vehicle tracking
- Transit security
- Transit fixed-route operations
- Transit maintenance
- Demand responsive transit operations
- Multimodal coordination
- Transit passenger and fare payment
- HOV monitoring
- Automatic passenger counters
- Communications systems
- Geographic information systems

Bus driver communicates with transit management center

Transit management systems (TMS) include the use of advanced navigation, information, and communication technologies to improve the operations of public transportation systems

Denver (AVL)-The Denver Regional Transportation District (RTD) has installed a global positioning system (GPS) on all of its 900 buses. With real time information on the location of its buses, the RTD provides better schedule adherence, makes adjustments in the event of service disrup tions, and updates departure-time monitors at downtown terminals.

Portland AVL-Portland's Tri-Met has placed GPS-based automatic vehicle location (AVL) systems on its entire fleet. Similar to Denver, Tri-Met's system is used for route and schedule adherence of its fixed routes. In addition, the AVL system helps in dispatching demand-responsive vehicles and making ADA-mandated advance trip reservations.

Columbus, Ohio Automatic Passenger Counters (APC)-The Central Ohio Transit Authority of Columbus, Ohio has installed automatic passenger counters in its vehicles that use infrared beams to count passengers entering buses. The data, which are removed every few days, are used for system planning, schedule adherence, and estimating route ridership. The counts are estimated to be 95 percent accurate.

Seattle's Smart Traveler Dynamic Ridesharing-Employees of the University of Washington who register for ridesharing matches through the World Wide Web and receive a match list and contact numbers. A geographic information system (GIS) is used to match origins and destinations.

Benefits/Costs: The transportation benefits of TMS applications occur primarily in two areas-the reduction in operating costs through more efficient utilization of fleet assets, and increased transit ridership due to enhanced service reliability and ease of using transit services. As shown in Table 6.3, these types of actions could have beneficial impacts on air quality, most likely in the context of pricing or other disincentives to single occupant vehicle use. Table 6.5 summarizes the benefits associated with TMS actions.

The following TMS projects illustrate the type of benefits that can be associated with their implementation.

Kansas City Computer-Aided Dispatch and AVL-The Kansas City Area Transportation Authority is using computer-aided dispatch and AVL to improve customer service and enhance service operations. This approach allowed the Authority to reduce the number of buses on these routes by seven, producing a $1.5 million capital cost savings and savings of $404,000 in operating costs per year.

Winston-Salem (North Carolina) Mobility Management-The Winston-Salem Transit Authority implemented automated dispatching/scheduling, AVL, and smart-card technology. System ridership increased by 18 percent. Amortized over five years, the cost of this system was 18 cents per passenger trip or 3 percent of operating costs.

Table 6.5: Benefits From TMS Applications

Market Package	Likely Benefits	Context Where Benefits May Accrue
Vehicle Trackrng	Improve on-trme performance Reduce field supervision	Higher benefits to areas with significant transit service reliability problems
Frxed Route Operations	Improve productivity of vehicles and labor	All transit scenarios
Demand Responsive Operations	Improve produdrvrty of vehicles Improve effraenq In routmg and trip scheduling	All transit scenarios
Passenger and Fare Management	Passenger convenience of common fare instrument Reduce cash handling losses Reduce costs of data collection	Benefits clearest where multiple agen-cres share services, transfers, etc
Transit Security	Faster response to Incidents Record of security Incidents	High benefits high less secure areas
Transit Maintenance	Schedule maintenance in Reduce maintenance/repair costs	All transit scenarios
Multimodal Coordination	Reduce transit travel times from signal priority for transit	Good institutional cooperation between traffic and transit managers IS necessary Level of benefits depends on ambient traffic levels

Source: FHWA 1996

AVL In Baltimore, Kansas City and Milwaukee-The use of AVL technologies in these three cities provided significant improvements in schedule reliability. In Baltimore, AVL-equipped buses showed a 23 percent improvement in on-time performance; in Kansas City a 12 percent improvement; and in Milwaukee a 28 percent reduction in late buses.

Portland, Automated Passenger Counters (APCs)-Portland's Tri-Met uses APCs to collect passenger data that is used in service planning. Each APC unit costs $4,500. Tri-Met has concluded that APCs provide easier and cheaper access to passenger data than that collected manually.

TMS technologies are particularly effective when coordinated with traffic management strategies. For example, a recent study on adaptive control for transit (i.e., preempting traffic signals to allow transit vehicles to pass through an intersection) showed in a simulated case that bus delays could be reduced by 55 percent and with 5-minute bus headways, the combined operating cost for buses and other traffic could be reduced 6 percent (Lin et al 1997).

The costs of TMS applications can range widely. (FIA 1996) provides a detailed listing of the costs for different AVL and APC operations in the United States. The cost of regional adoption of TMS actions for all transit operators in a metropolitan area could reach as high as $20 to $30 million.

The benefits of TMS applications occur primarily in two areas- the reduction in operating costs through more efficient utilization of fleet assets, and increased transit ridership due to enhanced service reliability and ease of using transit services.

TMS technologies are particularly effective when coordinated with traffic management strategies

A more extensive list of TMS proiect descriptions and impacts can be found in (Intelligent Transportation Society of America 1996; Federal Highway Administration 1995; U. S. DOT 199.5; Congressional Budget Xice 1995; Behnke 1993; Casey and Label1 1996; and Goeddell996).

Implementation: Given the perspective of implementing TMS actions within the context of a regional ITS strategy, the implementation characteristics of all the ITS actions are discussed on page 292 in the section entitled, Implementation of a Regional ITS Strategy." A compilation of TMS deployments is presented in (Casey and Label1 1996).

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Incident Management Systems (IMS)

Description: Traffic incidents (accidents, vehicle breakdowns, and disturbances to traffic flab) are one of the major causes of traffic congestion on urban highway systems. In order to respond quickly to such incidents, many urban areas have implemented regional incident management systerns. These systems consist of actions to address three major stages of an incident: 1) detection/verification, 2) response/clearance, and 3) recovery/information. Incident management systems (IMS) have been shown to be one of the most cost effective highway management strategies adopted in metropolitan areas. A more detailed discussion of IMS is found in Chapter 2, page 23.

Some examples of regional incident management systems include:

Connecticut Freeway Advanced Traffic Management System- Roadside radar detectors are used with closed circuit television to identifi and verify incidents. This information is fed into a centralized control center so that response strategies can be initiated.

Boston Incident Management System-Incident detection occurs through a variety of means, including cellular phone calls (approximately 28,000 monthly), government vehicles equipped with communications systems, cameras and vehicle probes, and closed circuit television. A tentralized traffic center coordinates incident response, with many responses provided by Samaritan service patrols (20 vehicles). Accident investigation sites have been constructed to permit removal of disabled vehicles from the travel lanes. Real-time traffic information is provided via telephone services (SmarTraveler), and variable message signs are located at key decision points.

Charlotte Incident Management- The Charlotte, North Carolina incident management program began in 1991 after a hazardous spill on I-75 caused the freeway to be closed for 11 hours. The program consists of surveillance through service patrols, cellular phone calls, citizen band radios, loop detectors, closed circuit television, and air patrols. A state police communications center is the coordinating unit for handling responses. Eleven variable message signs, four highway advisory radio systems, and a formal traffic diversion plan constitute the recovery component of the strategy.

Denver Incident Management Coalition-The Coalition began in 1992 with recommendations for a comprehensive incident management program. After an initial six-month courtesy patrol which showed a 15 to 1 benefit/cost ratio, the state DOT expanded the program to include other elements. Incident detection is provided through loop detectors, and closed circuit television. The courtesy patrol also provides incident detection. A traffic operations center manages the response to incidents using incident management teams and a pre-defined incident response system. Two radio frequencies are used-one for government agencies and one for the general public-to deliver information on road conditions.

Incident Management Systems can include:

- Network surveillance
- Regional trafficcontrol
- Surface street control
- Freeway control strategies
- Traffic management center
- Network performance evaluation
- Traveler information
- Enforcement strategies
- Incident response coordination
- Route guidance

Detroit's MITS Approach-The Detroit incident management program has relied on the application of ITS technologies to form the foundation of its strategy. A new Michigan Intelligent Transportation Center (MITS) continuously monitors 33 miles of freeway (future expansion to 150 miles) with loop detectors and closed circuit television. A service patrol works in conjunction with commercial traffic information services to detect and report incidents. An emergency response "call list" is maintained in MITS to guide the dispatch of emergency vehicles. Eight district communications centers are used to coordinate response. The MITS can control freeway traffic through on-line control of ramp meters and variable message signs.

i **Benefits/Costs and Implementation:** The benefits and costs of incident management implementation are discussed in Chapter 2. This discussion will not be repeated here. Given the perspective of implementing incident management systems within the context of a regional ITS strategy, the implementation characteristics of IMS are discussed on page 292 in the section entitled, "Implementation of a Regional ITS Strategy."

Electronic Toll Collection (ETC) Systems

Description: Electronic toll collection systems, known also as electronic toll and traffic management (ETTM) systems, provide an important capability to those operating a road to collect tolls for road users without having each user go through a toll booth. The components of an electronic toll collection system include: a transponder/tag for vehicles, an overhead mounted reader of these tags, a central computer, an antenna, a violation enforcement system, and an integrating controller that links the surveillance and enforcement systems (Center for Urban Transportation Research 1993). Approximately 12 toll agencies in nine states currently operate ETC systems, handling 250,000 toll transactions per day.

According to a survey undertaken by the International Bridge, Tunnel, and Turnpike Association in 1992, the characteristics of such systems can vary significantly. For example, the Florida Turnpike estimates that 20 percent of its transactions are electronic, whereas 80 percent of the vehicle movements on the Thomas Hatem Bridge in Maryland use electronic tolls (Smith 1996). In addition to the primary purpose of collecting tolls, ETC systems can also be used for other important purposes. For example, vehicles equipped with tags could be used in efforts relating to congestion pricing, advanced payment systems, traveler information systems, and freeway management systems (Yermack et al, 1995).

Benefits/Costs: The benefits and costs of ETC applications at a policy level are directly related to providing the technology that allows the true costs of highway use to be assigned to users, and at a site-specific level to the reductions in delay and congestion that occur at toll booths, while

Electronic Toll Collection systems can include such things as:

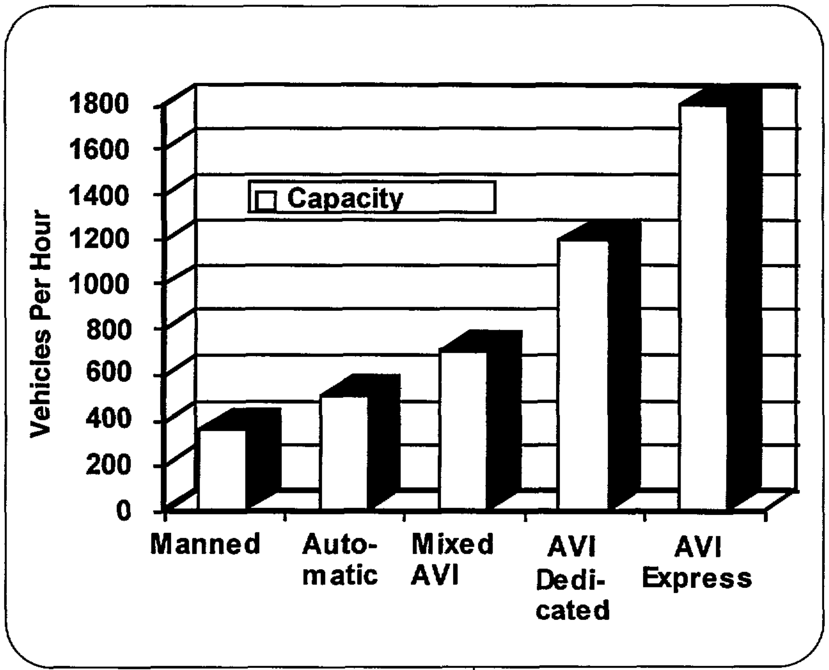
- Transponders
- Smart cards
- Variable toll pricing
- High occupancy toll roads (HOT)
- Congestion pricing
- HOV preferential treatment

at the same time increasing the capacity of these booths (Burris and Hildebrand 1996). Figure 6-4 shows the general relationship between average capacity and the type of toll collecting technology being employed (Pietrzyk 1994). As shown, the use of electronic toll collection strategies [through automatic vehicle identification (AVI) technologies] can increase conventional toll plaza lane capacity by between 40 and 400 percent. This increase in capacity results in reduced construction costs for toll booth lanes. For example, a Florida study [reported in (Pietrzyk 1994)] estimated that a 33 percent use of ETC at a toll booth with an hourly approach volume of 5,000 vehicles would reduce the number of lanes needed by four in each direction. If the participation rate increased to 66 percent, the reduction in lanes would be six in each direction.

Another example of ETC application includes the adoption of electronic debit accounts and transponders by the Oklahoma Turnpike Authority. By so doing, the Authority saw a decrease in operating costs at each staffed booth from $176,000 per year to $16,000, the cost for an equivalent electronic toll lane. Emissions were reduced at toll booths by six-to-one for hydrocarbons, four-to-one for carbon monoxide, and by two-to-one for nitrous oxide. Twenty-five percent of the toll accounts are for commercial establishments indicating travel time savings to these users (Public Technology, Inc. 1995).

Perhaps one of the more exciting applications of ETC technology has occurred on California's State Route

Figure 6.4: Average Capacity of Toll Plaza Lane By Type of Collection Strategy



Source Pietrzyk 1994

(SR) 91 in Orange County. The facility consists of a four-lane 16-km section of SR 91 that charges cars with one or two occupants tolls of $2.75 in rush hours and much lower rates during off peak hours. Three or more carpools are allowed on the facility free. The capital cost for constructing these median lanes was $134 million; toll revenues for 1996 were $6.5 million. By the end of 1996, 76,000 transponders were in use, with an approximate 25,000 vehicles per day using the monitored facility. These types of ETC applications are referred to as High Occupancy Toll (HOT) lanes.

Another application of ETC technology is found in commercial vehicle operations (CVO). Although not targeted to the collection of tolls, such technology is being used to minimize truck delay at weigh stations and other sites where electronic passage can occur. Examples of projects that illustrate CVO applications include: (U.S. DOT 1996; Cambridge Systematics, Inc. 1996)

"FasTrak 91 Express Lanes *in Orange County* California *uses Electronic Toll Colection*

In addition to the primary purpose of collecting tolls, ETC systems can also be used for other important purposes For example, vehicles equipped with tags could be used in efforts relating to congestion pricing, advanced payment systems, traveler information systems, and freeway management systems

Advantage I-75-Transponder-equipped trucks travel along I-75 with minimal stopping at inspection stations. Electronic clearance is based on upstream size and weight measurements that are transmitted to downstream stations thus avoiding the need for the truck to stop.

Green Light In Oregon-The Oregon Green Light project electronically verifies safety and weight information for vehicles and carriers from fixed and mobile roadside sites at normal highway speeds. In addition to transponder-equipped vehicles, video imaging is used to detect non-equipped vehicles. This technology allowed the State of Oregon to increase vehicle weighings by 90 percent and increase safety inspections by 428 percent between 1980 and 1989 with only a 23 percent increase in staff resources.

HELP/Crescent Project--One of the first multi-state CVO efforts, the Heavy Vehicle Electronic License Plate (HELP) project collected regulatory and licensing information on trucks, placed it on a smart card, and entered it into a central computer database. The card is read automatically as the truck moved along its route. Over 2,000 trucks were equipped with this capability.

I-95 Corridor Coalition-A non-profit organization (called TruckDesk) will provide accurate and timely information on construction, incidents, congestion, and weather to commercial vehicle operators. Information will be disseminated to motor carriers through pagers, fax, World Wide Web, dial-up services, satellite communications, and wireless communications. Other activities of the Coalition include electronic credentials administration; electronic data exchange; automated inspection screening, selection and reporting; and providing a forum for CVO program development and coordination.

The transportation benefits of CVO applications relate primarily to the increased efficiency of vehicle operations that can occur with a reduction in delays. In addition, these reductions in delays could result in improved safety at locations where truck queues would ordinarily form. The greatest benefit, however, is clearly to the vehicle operator. Use of two-way data communications, on-board computers, and automated vehicle location systems have allowed J.B. Hunt, Inc. to increase vehicle utilization by 20 to 2.5 miles/32 to 40 kms per truck per day. Other carriers report similar productivity gains. One carrier reported a 20 percent increase in loaded miles and the elimination of check calls; another noted an increase of 50 to 100 additional miles/80 to 160 kms per day and a decrease from 100 percent to 30 percent in driver turnover; yet another reported 16.9 percent additional shipments, 5.7 percent fewer deadhead miles, 3.8 percent fewer cancellations, and 24.5 percent expedited pickups and deliveries (Federal Highway Administration 1995). A study of real-time diversion of truckload carriers predicted an additional productivity improvement of 6 percent.

In addition to the savings to vehicle operators, public agencies can accrue cost savings due to the more efficient use of inspection and enforcement personnel. For example, the benefits of the HELP/Crescent Project, projected nationally, would mean reductions in tax evasion ranging from $0.5 to $1.8 million per state; savings of $5.6 million annually due to reductions in overweight loads; and reductions in the operating costs of a weigh station of up to $160,000, with an additional annual savings of $5 to $9 million in reduced credentials and safety requirements associated with foregone accidents.

Implementation: Similar to previous ITS actions, ETC implementation will include the participation of private sector organizations; in the case of CVO, motor carrier operators. ETC should be viewed from the perspective of an integrated ITS transportation system which is discussed in the section entitled, "Implementation of a Regional ITS Strategy" on page 292.

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Electronic Fare Payment systems can include such things as:

- Smart cards
- Integrated fare structures
- Variable fare pricing
- Magnetic tickets
- Automated trip payment

Electronic Fare Payment System (EFPS)

Description: Electronic fare payment involves automated trip payment through the use of non-cash media credit cards, debit cards, magnetically encoded fare cards, or advanced card technology such as smart cards (Schweiger, Kihl, and Labell 1994). Smart cards include an electrical circuit, varying from a strict memory type to a microprocessor, that is embedded into a credit-card sized fare card. For most modern applications, the smart card only needs to be brought in close proximity to a reader for data to be transferred (Transportation Research Board 1994). The smart card is usually part of a prepaid system in which payments to the transit property are stored on the smart card and then the appropriate fare is deducted when a trip is made. There are two major classifications of smart cards: contact cards that require physical contact between the card and the read-write unit, and a contactless card which can be read by passing the card close to the read-write unit. A likely evolution in the use of smart card technology is for the card to become a general purpose debit card that can be used for all types of purchases.

A survey of 54 transit properties in 1996 indicated that 29 were likely to adopt a magnetic stripe (stored value) fare strategy, 12 were adopting a contact smart card approach, 14 a contactless smart card program, 10 would provide for credit card use, and 10 would allow debit cards (Transportation Research Board 1997).

Examples of electronic fare payment systems include: (Public Technology, Inc. 1995; Transportation Research Board 1997)

Electronic Fare Payment, Phoenix- Phoenix Transit uses magnetic card readers which accepts credit cards for payment of transit fares. Accounts are totaled and billed monthly. The rate of invalid credit card use is estimated to be about 2 percent. A smart card called BusCard Plus has been issued to approximately 10,000 passengers.

MARTA/VISACash Project-The Metropolitan Atlanta Rapid Transit Authority (MARTA) has entered into a partnership with VISA and three banks in developing a smart card program that currently can be used for MARTA fares as well as for other purchases. VISA covered the cost of read-write units for two turn stiles in every MARTA subway station. The transit agency in this case became another "merchant" in the smart card program.

Ventura County, California Coordinated Smart Fares Cards- Seven transit agencies in Ventura County allow use of smart cards for payment on buses. Known as the Passport, this smart card is a monthly pass that can be used on any bus in the county, thus providing for easy transfers. In addition, the smart cards will be used to identify rider types that can be used in transit service planning

TransLink in the Bay Area- TransLink was the first on-board joint transit regional fare collection program in the United States. A magnetic stored value ticket was available to individual passenger to use and transfer among the several transit operators in the Bay Area. Special discounts were available for bus/rail transfers using the TransLink ticket. The transit operators in the region are now in the process of adopting a contactless smart card program that will replace the magnetic stored value ticket.

Los Angeles Metrocard- Magnetically-encoded Metrocards, the size of a normal credit card, are sold in increments of $10 and can be used on all services in Los Angeles County. The purpose of this program was to eliminate paper transfers, provide inter-transit property fare media, reduce cash transactions, and enhance passenger convenience.

Washington D.C. Metro Go-Card- In 1994, Washington Metro installed read-write units in 24 rail stations, on 21 bus routes, and five park-and-ride lots. Called Go-Cards, these contactless smart cards also provide data on ridership and revenue to central headquarters. Dam from rail, bus, and parkiig subsystems are transmitted via modem to a central computer system.

Wilmington, Delaware, SMART DART Project-The Delaware Authority for Regional Transportation (DART) will be equipping 135 buses with smart-card readers. Smart cards will be provided to bank customers and made available to non-bank customers. Major employers participating in employee transportation programs could provide smart cards and have funds directly entered through on-site add-value machines.

Benefits/Costs: Electronic fare payment can provide many benefits to the transit agency and to the customer. The survey of 54 transit prop erties discussed earlier indicated that the major goals (and thus benefits) of adopting an electronic fare payment program were (in order of priority):

- Improve convenience for riders
- Improve ability to collect needed data
- Improve ease of administration
- Improve fare system security and accountability
- Reduce cost of fare collection and processing equipment
- Improve ability to modify fare structure and policies
- Improve ability to integrate with other on-board technologies
- Improve throughput
- Create "seamless" regional transit travel
- Integrate payment with other transportation services
- Integrate payment with non-transportation uses

A recent study of fare policies, structures, and technologies listed the following benefits and costs associated with electronic fare payment systems (Fleishman et al 1996).

- The advent of electronic fare payment has facilitated the use of stored value as a prepaid option. Stored value offers the convenience associated with any type of prepayment and allows the rider to decide how much to prepay at a

Electronic fare payment invo/ves automated trip payment through **the use of non-cash media credit** *cards, debit* **cards, magnetically** *encoded fare cards,* **or** *advanced card technology such* **as** *smart cards.*

given time. This option can also "mask" the complexity of a fare structure to the rider because he or she does not have to know the exact fare for a particular trip.

- Electronic fare payments enable agencies to offer various fare options and to modify the fare structure easily. For instance, electronic stored value media permit differentiation of fares by payment option (e.g., time-based, trip-based, value-based, or combinations thereof), time of day, mode, nature of minimum purchase price, and discount or bonus offered. Because electronic payment can enable agencies to offer a range of fare options and structures with a single fare medium, electronic fare payment also can facilitate integration of multiple operators in a region.

Electronic fare payments enable agencies to offer various fare options and to modify the fare structure **easily**

- The use of electronic fare payment can considerably reduce bus operators' fare collection responsibilities, thereby minimizing potential operator and rider conflicts. The reduction in the need for operators to handle and inspect transfers or flash passes can result in reduced dwell time, thereby improving service reliability.

N Electronic fare payment allows the collection of more accurate and comprehensive ridership data (by fare category); this can permit better analysis and forecasting of fare changes, as well as improved understanding of rider-ship patterns by route and time period-and thus better service planning.

- The use of electronic media facilitates the generation of increased revenues through reduced fare evasion and abuse and through better revenue control.

- Agencies can receive revenue from unused value on stored value cards-the agency benefits from the "float" associated with prepayment in general, as well as the remaining value on cards never actually used for purchasing trips.

- Electronic payment also offers opportunities related to expanding the existing capabilities of the fare media themselves (e.g., through regional fare integration, multiple use cards, and post payment and employer billing applications).

- The maintenance and repair costs for electronic payment-and distribution-equipment can be expected to rise (at least initially), because of the need for more highly trained personnel. Use of these technologies, however, may result in net fare collection cost savings because of reductions in the numbers of overall fare collection staff.

- The cost of purchasing and implementing electronic fare collection equipment can be high, depending on the specific types of equipment involved. The unit cost of the fare media can also be high (i.e., for smart cards).

Implementation: Given the perspective of implementing EFPS actions within the context of a regional ITS strategy, the implementation characteristics of all the ITS actions are discussed on page 292 in the section entitled, "Implementation of a Regional ITS Strategy."

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Railroad Grade Crossing Warning System

Description: Potentially one of the most dangerous situations on the road system is where roads cross railroad tracks, known as highway-rail grade crossings. In 1994, there were approximately 166,000 such crossings in the United States. Accidents at these crossings totaled 4,900 with 600 fatalities and 1,600 injuries. With freight rail volumes increasing and with more urban areas considering the implementation of commuter rail systems, additional attention should be given to enhancing the safety of vehicular movements across these crossings. ITS applications that can provide this increased safety include such things as advanced train control systems, automatic equipment identification, automatic grade crossing health and status monitoring, automated enforcement of grade crossing regulations, linking train control technology to highway traffic control systems and vehicle information systems (Bartoskewitz and Richards 1995).

Examples of ITS technologies that can be applied in railroad grade crossing warning systems include (Federal Railroad Administration 1996):

Advanced Train Control (ATCS)- ATCS is a microprocessor/communications/ transponder-based system designed to provide more direct control over train operations. With such a system, train crews can be notified of known obstructions on the rail line and thus centralized authority be provided over train movement.

Positive Train Separation/Positive Train Control-These technologies provide electronic monitoring and control systems for train operations. In essence they provide intervention in train operations to maintain speeds at or below that maximally allowed.

Vehicle Proximity Alerting System- A priority set of vehicles (e.g., school buses, large trucks, hazardous materials haulers, and emergency vehicles) would have installed in-vehicle warning devices that warned of approaching trains. By estimating the time-of-arrival of trains at a grade crossing (with real-time information on train position), these vehicles can

Railroad Grade Crossing Warning Systems can include such things as:

*Advanced train control

- Positive train separation
- Vehicle proximity alerting

N Traveler informatlon

. Traff ic control systems

&Automatic vehicle location

One of the most dangerous situations on the road system is where roads cross railroad tracks

be alerted far in advance of any potential collision (U.S. DOT 1996). Communication between train and vehicle usually occurs via radio. More advanced systems would provide drivers with information on estimated time of arrival of the train, direction of travel, and speed. These systems would also include technologies to locate trains and vehicles, enhanced communications, and improved crossing warning devices.

For a discussion of grade crossing issues as they relate to light rail facilities in urban settings, see (Korve et al 1996).

Benefits/Costs: As the name suggests, the primary benefits of the railroad grade crossing warning systems relate to reduction in the 4,900 accidents that occur annually. At this time, no projects have been implemented using this approach that indicates costs or actual benefits.

Implementation: Of all the ITS market packages, those relating to railroad grade crossing warning systems are most likely to need the involvement of the private sector to achieve desired goals. Many of the train and vehicle sensors and vehicle driver information displays will be provided by vehicle manufacturers and train operators. Within the context of regional transportation planning, however, hazardous location identification and data collection on system performance will still be necessary.

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Emergency Management (EM) Systems

Descriptions: Emergency management systems fall into three categories: 1) automated emergency vehicle notification upon verification of an incident, 2) the dynamic routing of emergency vehicles in conjunction with special priority given through a traffic management center, and 3) the initiation of emergency assistance requests with the follow-up response from emergency management personnel.

Examples of the types of projects that illustrate EM applications include the following (U.S. DOT 1995). In addition, a regional system of emergency notification and response is a natural component of a regional Freeway Management System and a Regional Multimodal Traveler Information System.

Collision Notification, New York- An advanced in-vehicle automated collision notification system will be installed in 1,000 cars in western New York State. This system determines that a serious collision has occurred and summons emergency medical services.

Colorado Mayday System-Two thousand vehicles will be equipped with global positioning systems (GPS) and cellular phones to communicate with a regional control center. This demonstration will assess the structure, responsibilities and service levels of a traveler assistance center.

Dynamic Truck Speed Warning, Colorado-A sensor on I-70 west of Denver detects truck weights and warns drivers of safe truck speeds at the start of a long downgrade. Some speeds of runaway trucks at this location have reached 110 mph, so improved truck driver warnings are designed to make the danger apparent.

Railroad Grade Crossings-Vehicle proximity alerting systems are being tested as a potential means of alerting special classes of vehicles (e.g., school buses, large trucks and emergency vehicles) to on-coming trains. Surveillance at highway-railroad grade crossings can provide near instantaneous notification of an accident occurring.

Benefits/Costs: The benefits of EM systems are shown in Table 6.6.

Implementation: Given the perspective of implementing EM actions within the context of a regional ITS strategy, the implementation characteristics of all ITS actions are discussed in the following section.

Table 6.6: Expected Benefits of EM Applications

Market Package	Likely Benefits	Context Where Benefits May Accrue
Emergency Response	Assumed reduction in response times through system coordeinated response	Higher level of benefit realized in areas with multiple jurisdictions and Independent response agencies
Emergency Vehicle Routing	Unknown level of benefits	
Mayday Support	Anticipated faster routing of calls, shorter response times	Higher level of benefit realized in areas with multiple jurisdictions Higher benefits in rural areas

Source. FHWA 1996

EM applications include:

- Emergency response
- Emergency routing
- Mayday support

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IMPLEMENTATION OF A REGIONAL ITS PROGRAM

As noted in the previous sections, the implementation of ITS actions often requires the participation of many different organizations and groups, with different actions exhibiting different implementation characteristics and timeframes. The major theme of this chapter has been that an ITS program can provide an important foundation for many of the types of transportation initiatives that can take place in a metropolitan area. Therefore, it is critical to integrate ITS with the regional transportation planning process which is itself designed to provide a comprehensive look at the most cost effective solutions to the transportation problems facing a community. The "implementation" of ITS will thus be discussed in two parts-looking first at the integration of ITS into transportation planning, and second, focusing on the institutional issues that will have to be addressed in any implementation of an ITS program.

Importance of System Architectur- With the many different technologies involved with ITS applications, guidance is necessary to develop compatible systems and system connections. The U.S. Department of Transportation has facilitated the development of a National ITS Architecture which "defines the functions that must be performed, the subsystems that provide these functions, and the information that must be exchanged to support the user services" (Federal Highway Administration 1996). The benefits of having a common architecture are that ITS products can be applied to markets throughout the United States, and thus reduced costs will accompany more efficient operations through economies of scale and competition. The National Architecture has communications, transportation and institutional elements attached to it, all of which must work together for ITS to be successful.

The Federal Highway Administration lists the following benefits for the National ITS Architecture: (FHWA 1997)

- Identifies where standards are needed for system interoperability and prioritizes the development of these standards.
- Provides an open-ended framework that allows ITS applications to be added when desired or needed.
- Promotes modular, off-the-shelf products that support open-ended ITS. Use of the National ITS Architecture discourages closed and proprietary systems that can reduce long-term costs.
- Provides assistance for procurement and implementation by providing guidance for product cost estimates and identifying criteria to evaluate system performance.
- Promotes lower-priced ITS equipment and components due to economies of scale and competition through multiple vendors.
- Identifies new funding sources by strongly encouraging private sector participation in ITS.

- Assists agencies in developing a strategy for phased ITS deployment.
- Builds upon existing transportation and communications infrastructure.
- Provides a framework for creating an architecture that will integrate legacy systems with new ITS applications.
- Provides confidence for transportation agencies and elected officials on the success of ITS.

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THE LINKAGE BETWEEN ITS AND TRANSPORTATION PLANNING

In Chapter 1, the mobility and accessibility goals of transportation system changes were portrayed as being affected by three major categories of actions -demand management, land use, and changes to the supply of transportation. Figure l-2 showed ITS as being one of the major types of action that could be considered in the process of improving the condition and performance of a region's transportation system. In reality, ITS actions can be considered as part of the Toolbox from many perspectives. As noted in the Interim Handbook on ITS Planning, the appropriate role for ITS in the context of transportation planning includes: (JHK & Associates, Inc. 1996)

- ITS can represent both direct operational initiatives (e.g. freeway and network traffic control systems and incident management systems) as well as actions that support other strategies (e.g. user services that support ridesharing and transit operations).
- ITS strategies interact with other transportation strategies in impacting traffic congestion and mobility (e.g. an HOV ramp meter bypass system needs to interact and coordinate with the provision of transit service and ridesharing efforts).
- ITS may sometimes need to be considered as a competing alternative with other transportation strategies.
- In a planning environment with constrained resources, ITS needs to be considered for its investment merits along with other strategies.
- There are elements of ITS that are unique and that need to be considered at a regional level independent of other transportation strategies in establishing cost-effective systems. For example, a communications system or traveler information system should

be thought through at a regional level to provide for economies of scale, consistency among geographic areas, and coordination among agencies.

Given the operational focus of many ITS actions, the consideration of ITS in the context of transportation planning might very well provide an important operations orientation to the transportation plans and programs that result from the planning process. Clearly, the appropriate role for ITS in metropolitan areas will vary from one locale to another, depending on a variety of characteristics. Table 6.7, for example shows how ITS actions might vary from one area to the next. Importantly, a general theme that runs throughout this Table is that when opportunities exist, ITS capability should be incorporated into the transportation infrastructure to provide the foundation for future solutions to congestion and mobility problems.

The goal of ITS implementation is for ITS actions to be considered as part of the transportation planning process.

Not only should ITS actions be considered during the development and updates of regional transportation plans, but they should also be considered in subarea, corridor, and major investment studies (see Chapter 3 for a discussion of major investment studies). By reducing the scale of planning from the regional level to a smaller area, the linkage between different solutions and specific problems becomes more apparent. For example, the need for computer-controlled, synchronized traffic signalization is more evident when the focus is on a specific arterial highway than at a metropolitan scale.

Although the ultimate goal of ITS implementation is for ITS actions to be considered as part of the transportation planning process, there is an important role within this process for conducting an ITS strategic planning process or strategic assessment. The purpose of this process is to link ITS market packages to the different types of problems and user needs in the region. A vision of how ITS fits with the general transportation direction of the metropolitan area is also part of this process. Importantly, the foundation for ITS integration and coordination among the different market packages and among the various implementing agencies is developed by defining a regional ITS architecture. Similar to the national architecture discussed at the beginning of this chapter, a regional architecture is a framework for providing consistency and compatibility in the implementation of ITS initiatives that could occur at different times and/or at different locations.

The possible products from a strategic planning process might include: (JHK & Associates, Inc. 1996)

"Organize the Study Effort and Establish Core Stakeholder Coalition

- Listing of stakeholders
- Work plan and schedule
- Outreach and consensus-building Plan

Develop ITS Vision

- Listing of ITS-related themes or vision statements
- Initial assessment of funding situation and implementation barriers

Define Problems, Goods, and Existing systems

- Documentation of existing conditions related to strategic plan
- Study area map
- Listing or graphic representation of problems and opportunities
- Listing of ITS-related goals and objectives
- Documentation of existing ITS components in study area

Screen Market Packages

- Mapping of market packages against problems and goals
- (Alternate) Environmental scan of ITS elements
- (Alternate) Strengths-Weakness-Opportunities-Threats analysis
- Scan of ITS elements
- Listing of market packages to be further evaluated

Define Market Package Plan

- List of performance criteria by market package
- Analytical results of market package evaluations
- Documentation of recommended market packages by geographic area

ldentify Desired Functional Capabilities

- List of potential system requirements by market package
- Functional requirements definition by subsystem and technology area

Define Regional Architecture

- Charts and description of logical, organizational, and physical architecture
- List of feasible technologies to support the market packages
- List of recommended technologies for near-term ITS program

Define Operational Strategies

- Project definitions, integrated with other transportation projects, where appropriate
- Operations and maintenance plans for the ITS programs
- Potential sources of funds (implementation and operating) by project
- Potential public private partnerships
- Implementation plan for ITS program(s)

Develop the Strategic Deployment Plan

- Strategic deployment plan, including an action plan
- TIP project summaries for near-term projects
- Potential material for integration into transportation plan

Monitor / Evuate the ITS Activities

- Monitoring and Evaluation Plan (could be integrated with monitoring activities of the overall planning process)
- Databases designs to accommodate monitoring and evaluation data"

When opportunities exist, ITS capability should be incorporated into the transportation infrastructure to provide the foundation for future solutions to congestion and mobility problems.

Table 6.7: Metropolitan Area Characteristics and ITS

Characteristic	Considerations for ITS Development
Metropolitan Area Size	
Large	Tends to have higher levels of congestron. with greater potential benefit from ITS Bus system will be larger and more complex operationally Should result in greater TMS benefits Freeways typically operating closer to capacity for larger numbers of hours Impact of incidents will be greater under these condrtrons Navigation within and through area will be more difficult for unfamiliar drivers. RMTIS will have to recognize this.
Medium	Congestion levels will likely be lower but still significant Emphasis on ITS will be dependent on special characteristics of the region
Small	ITS will likely be warranted for "niche" areas relating to special charactenstrcs of the area Benefits from wide spread application will be reduced if mobility is primarily dependent on a single facility (e.g freeway), ITS programs should focus on the facility In some smaller areas, major generators may dominate travel patterns (e.g , universities, tourist attraction, etc) These should be the focus of ITS activities
Metropolitan Area Growth Rate	
Rapid	Transportantion rnfrastructure is likely expanding to keep up with growth. ITS should be planned in concert with other infrastructure to economize Potential additonal funding exists from private sector as areas are developed.
.ow	Opportunrtres for innovative financing may be more limited If existing communications rnfrastructure does not exists, wireless technologies or leased communications lines may be more of a consideration.
Right-of-Way Availability	
Ample	Roadway rnfrastructure is expandable. Comunications systems should be planned in close coordination with infrastructure planning There may be less incentive to deploy ITS immediately unless other financial constraints make infrastructure expansion unlikely in the near term A regional philosophy against highway expansion may also argue more for an ITS approach
Limited	Limit options on roadway infrastructure expansion may increase potential for ITS deployment Creative solutions to communications may be required if communications corridors are restricted. Limited ROW may mean that shoulders are being or will be used for travel lanes. The Importance of incident management Increases Regions typically also look more toward transit and TDM strategies under these condrtrons. Opportunities thus exist for TMS applications Incident access by emergency vehicles may be limited. therefore operational plans for EM access should be part of strategy development
Existence of Parallel Routes	
Numerous	This is an Ideal opportunity to showcase traveler information systems. Strong, operational support will be needed to deliver an effective RMTIS Opportunities may also exist for dynamic routing of transit vehicles
Limited	Pm-Trip information will be more important than areas having alternate routes. Incident management will take a more important role
Weather	
Snow/Ice	ITS can enhance warning coverage for hazardous conditions
Rain/Fog	Automatic speed advisory systems could help reduce accidents dunng hazardous condrtrons. These will be targeted to specific locations.

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Table 6.7: Continued

Characteristic	Considerations for ITS Development
Special Generators	
Tourist	Most significant characteristic is presence of many unfamiliar travelers RMTIS may be important application in these areas Opportunities exist in conjunction with tourist operators to fund applications ITS should be tied in with special transportation services that may exist
Airports	RMTIS should be oriented to needs of airport users ITS applications can focus at major gateways to the airport Electronic collectron of parking fees is an ideal application
Stadiums	ITS can focus on major entry and exit points Opportunities may exist to automate certatn traffic management features (e.g traffic responsive signals). RMTIS can focus primary on parking funding opportunities may exist by integrating RMTIS with other information needs such as event dates
Colleges	RMTIS can focus on visitor needs (sporting events, graduation. etc.) ITS applications may exist for parking management ITS may be planned in conjunction with security features Colleges are usually well served by transit TMS features therefore applicable
Transit Orientation	
Rail	Bus routing will normally be supportive of rail system ITS emphasis will be on transit fleet management and transit information systems Extensive or emerging HOV network Many opportunities exist to support HOV system, including ramp metering, RMTIS, automated gate control, etc ITS applications to enhance ndeshanng should be considered
Major Bus	Capture rates for transit will likely be lower than rail city Fleet management and fare ITS applications will enhance service Transit agencies should work with traffic agencies to assess feasibility of bus pre-emption of signals Express bus may be cost effective. Incident management and HOV applications
Presence of Toll Facilities	
Extensive	Potential for electronic toll collection Economies of scale will allow significant market penetration of ITS technologres Congestion pricing strategies might be Implementable with ITS technologres.
Emerging	Electronic toll collection through ITS technologies a definite possibility
***Topographic* Features**	
Rivers	River crossings could have ITS surveillance to minimize incident delays Shoulder access on bridges is limited. Incident response strategies ATIS should focus on possible alternate routes Tolls and HOV facilities might exist and thus be ossible ITS applications
Hills	Limited availability of parallel routes Incident response critical. Additional surveillance many be warranted at bottleneck points
Lakes	Road system may be fragmented or discontinuous. RMTIS strategies useful
Commercial/Employment Base	
Heavy Industry	Truck traffic will be high. CVO applications could be important Substantial opportunities for ITS applications at intermodal terminals
Business Parks	ITS applications should support transit and ndeshanng strategies that will reduce vehicular demand to these areas

Source: JHK & Assocs. 1996

An example of an ITS strategic planning process is found where the Connecticut DOT sponsored a comprehensive study of ITS deployment in Hartford (ConnDOT 1995). This effort included a comprehensive assessment of current problems, the development of an ITS vision for the region, a determination of priority ITS applications, and recommended deployment of ITS actions over a 10-year timeframe. Table 6.8 shows the list of priority ITS applications that resulted from this process. Importantly, the Connecticut ITS effort involved numerous stakeholders and user groups throughout the planning process so that the day-to-day experiences of transportation users were brought into the deliberations of what priorities should be placed on ITS deployment.

Some important lessons have been learned from early efforts at ITS strategic planning (JHK & Associates, Inc. 1996).

- A realistic assessment of funding is needed as an underpinning of ITS strategic assessments.
- A greater effort should be made in strategic assessments to craft the agreements and partnerships that will sustain implementation.
- Make appropriate connections with other elements of the planning process and with other planning documents.

Table 6.8: ITS Service Priorities in Hartford

Capitol Region ITS Service Priorities	Rating
High Priority "Core" Services	
Pre-Trip Traveler Information	5
En-Route Driver Information	5
Traffic Control	5
Incident Management	5
Publrc Transportation	5
Route Guidance	4
Moderate Priority "Core" Services	
Electronic Payment (Fare) Services	4
Ride Matching and Reservation	4
personalized Publrc Transit	4
Traveler Services Informatron	3
En-Route Transit Information	3
Moderate Priority "Supplementary" Services	
CV Administrative Processes	4
Demand Management and Operations	3
Emergency Vehicle Management	3
En-Route Transit Informatron	3
CV Electronic Clearance	3
CV Automated Roadside Safety Inspection	3
CV Hazmat Incident Response	3
Publrc Travel Security	3

Ratings 5 = Highest Priority
1 = Lowest Priority

CVO services are not considered "Core" regional services since they typically Involve statewide or Interstate institutional Issues.

Source ConnDOT 1995

- Improved interagency communication and coordination is a side benefit of an ITS strategic assessment.
- ITS must be related to agency functions. The institutional concerns over ITS tend to be considerably more significant than the technological ones.
- Do not commit to specific technologies too early in the process.
- An ITS strategic assessment should ultimately define implementable projects, not merely concepts. The products should define actual projects with real timeframes, real costs, and real benefits.

INSTITUTIONAL CHALLENGES IN IMPLEMENTING ITS

ITS strategies can have technical challenges associated with their implementation. However, in many cases, the process is slowed down because of serious institutional issues (U.S. DOT 1994). These institutional challenges likely relate to the ability of transportation agencies to accept ITS solutions to problems that had been traditionally "solved" with new construction. In addition, given the significant role that private sector groups would have in many of the ITS deployments, many questions arise on what is the appropriate role for government agencies, and how could such large scale technological approaches to transportation system management occur within the context of regulatory, financial, and legal constraints associated with contracting and purchasing of services? In addition, partnering is an important ingredient of successful ITS ventures, and yet what are the terms of such partnerships that would be acceptable to both public and private sector participants?

A recent survey of the institutional issues, barriers, and problems to ITS planning found that these concerns could be grouped into six major categories-organizational, leadership and management, legal and regulatory, technological, ITS impacts and benefits, and financial (JHK & Associates 1996). Table 4.9 shows the different types of issues that fall within each category. Many of these non-technical issues can be dealt with by incorporating ITS into the regional transportation planning process which provides an open forum for all interested parties to understand and resolve such issues. However, others must necessarily be the product of legal and negotiated compromises. The concept of user services provides a good mechanism to identify the benefits associated with each market package and to portray these benefits to targeted groups.

Perhaps one of the most critical challenges to ITS strategies is developing the finance package that often includes revenue from many different sources. In particular, where risk is involved, who will provide the financing that accounts for varying levels of risk? Figure 6-5, for example, illustrates the three major approaches to risk-taking: public agencies adopt risk where the technical risk is high and the potential for user payments is low; private groups can take the lead when technical risk is low, but the potential for direct user payments is high; and a partnership of the two

A recent survey of the institutional issues, barriers, and problems to ITS planning found that these concerns could be grouped into six major categories-organizatronal, leadership and management, legal and regulatory, technological, ITS impacts and benefits, and financial.

Table 6.9: ITS Institutional Issues

Barrier	Breadth	Impact	Resolution Potential	Unique to ITS
Organizational				
Perceptron of loss of control	Moderate	Moderate	High	U
Public agency not accepting ITS	Moderate	Moderate	High	U
Differing agency objectives	Moderate	High	Moderate	A
Thinking limited on solutions	Moderate	High	High	A
Difficulties cooperating cross border	Moderate	High	Moderate	C
Cultural differences between public and private organizations	Moderate	High	Moderate	A
Lack of trust	Moderate	Moderate	Moderate	C
Unclear def'n of goals and roles	Low	Moderate	Moderate	A
Resistance to change	Low	Low	High	A
Lack of staff continuity	High	Moderate	High	A
Leadership and Management				
Lack of advocates at the staff level	Moderate	High	High	C
No advocates at top management	High	Moderate	Moderate	C
Failure to provide leadership	Moderate	High	Moderate	C
Lack of Interagency communication	High	Moderate	High	C
Lack intra-agency communication	Moderate	Moderate	High	C
Too large steering committee	Moderate	Low	Low	A
Inadequate committee representation	Moderate	Moderate	High	A
Unempowered steering committee	Moderate	High	Moderate	C
Inability to maintain Interest	Low	Moderate	High	C
Devoting planning resources to low priority areas	Low	Low	High	C
difficulties in agencies' contracting	Low	High	Moderate	C
Failure to show progress	High	Moderate	Moderate	A
Ignoring maintenance and opns staff	Moderate	Moderate	High	U
Tying to accomplish too much	Low	Moderate	High	A
Lack of written documentation	Moderate	Moderate	High	C
Uncertainty over long commitment	High	High	Low	A
Overly complex procurement	High	Moderate	Moderate	A

U = Unique to ITS
A= Ampldied, not unique but more prominent in ITS
C = Common to all transportation projects

Table **6.9: Continued,** *Source: JHK & Assocs. 1996*

Barrier	Breadth	Impact	Resolution Potential	Unique to ITS
Resources Personnel **and Facilities**				
Lack of specialized technical skills	High	High	Moderate	U
Lack of familiarity with ITS	Moderate	Moderate	High	U
No knowledgeable ITS spokesperson	Moderate	Moderate	Moderate	C
No knowledgeable public/private partnership expertise	High	Moderate	Moderate	A
Unacceptable business risk	Moderate	High	Low	A
Technologies				
Fear of technological obsolescence	Moderate	Moderate	Moderate	U
Inattention to details	Moderate	High	High	A
Lack of technical standards	Moderate	Moderate	Moderate	U
Limited communication frequencies	High	Moderate	Moderate	U
ITS Impacts and Benefits				
Lack of information on ITS impacts	High	Moderate	Low	A
Redistribute traffic in communities	Low	Moderate	Low	U
Leaning to capacity increases	Moderate	High	High	C
No explanation to officials	Moderate	Moderate H	High	U
Public reaction against technologies that compromise privacy	Low	High	Low	U
Environmental impacts	Moderate	Low	Low	C
Low visibility of ITS benefits	High	High	Moderate	U
Inequitable allocation of benefits	Moderate	Moderate	High	A
Perception that ITS doesn't solve problems	Low	Moderate	Moderate	U
Legal and Regulatory				
Liability concerns	Low	High	Moderate	A
Regulatory limitations	High	Moderate	High	A
Difficulty in intellectual property rgts	Low	High	Moderate	U
Regulations on cross border projects	Low	High	Moderate	C
Organizational conflict of interest	Low	Moderate	High	A
Financial				
No state/local funding	High	High	Moderate	C
Lack of funding for opns and main.	High	High	Moderate	A
Justifying expense of ITS	Moderate	High	Low	A
Low priority allocation to ITS	Moderate	High	Low	A

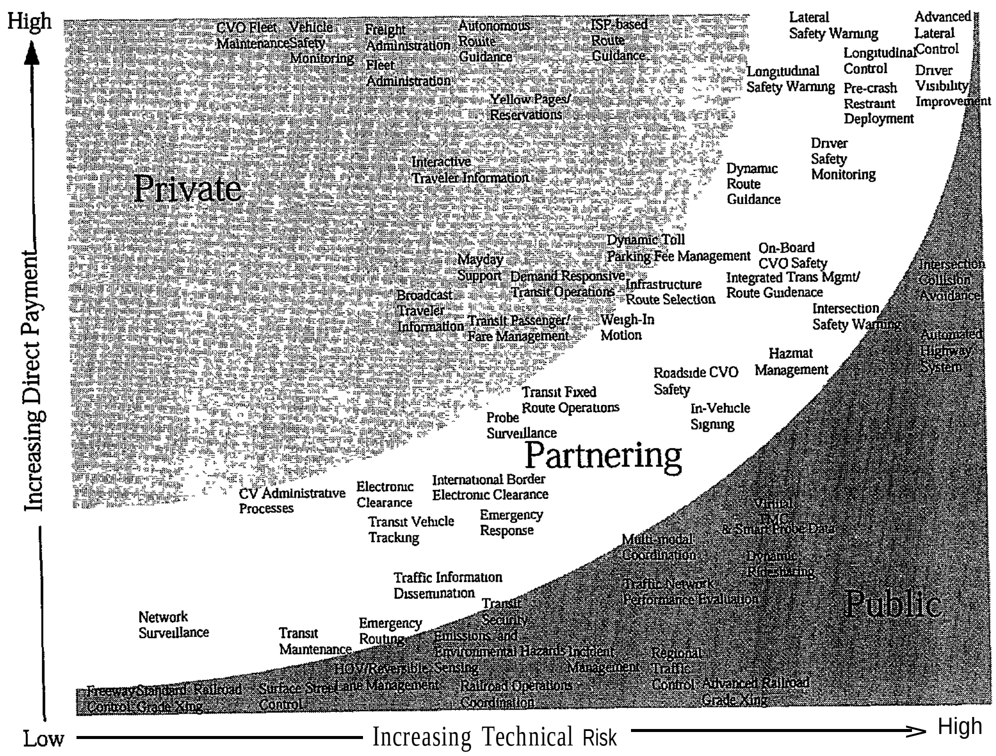
Source: JHK & Assocs **1996**

can occur for combinations in-between. This Figure, of course, is simply an illustration; the reality is that there will likely be many exceptions to the institutional lead suggested in Figure 6-5. However, the critical aspect of ITS implementation, the institutional and financial aspects of successful deployment, must be dealt with.

Perhaps the best guidance on how to achieve this success is to look at lessons learned from early ITS projects. Some important lessons include the following: (JHK & Associates, Inc. 1996)

- Customer orientation-The delivery of ITS projects and programs needs to address the needs of the customer: the commuter, traveler, transit rider, goods transported, etc. Long-term success will depend on the perception that a useful service is being provided.
- Problem-sobing emphasis-This reinforces the customer orientation. The focus should be on how ITS is addressing problems or is improving travel convenience and safety to the public. Elected officials must understand how ITS can be their ally in gaining the favor of their constituents.
- Integration-ITS is one of a broad array of techniques to address today's transportation problems. ITS is often used to its best advan tage when integrated with other

Figure 6.5: Market Packages and Institutional Partnerships



Source FHWA 1996

techniques. It must work in coordination with other approaches, not merely be in competition with them.

- *Partnerships-Substantial* ITS deployment cannot be achieved by a single agency. Partnerships must bring agencies together across geographic boundaries and across lines of functional responsibility. For the purposes of long-term funding and coordination, partnerships must bring the public and private sectors together.

- *Communication* with elected officials---Elected official support is essential to long-term success. This support must extend across election cycles to maintain continuity. Developing this continuing sup port requires continued attention, information, and education.

- *Maintaining Credibility*-The public will mistrust projects that do not work predictably and consistently. Failure to maintain credibility will ultimately erode support for ITS. Maintaining credibility goes hand-in-hand with customer orientation.

- *Attention to detail*-Success in ITS is in the details. The details are important in all phases of ITS implementation, from construction to maintenance to operations. Decisions need to be carefully weighed on striking the balance between relying on proven technology versus moving forward with the latest technology.

- *Patience*-Like most transportation projects, many ITS projects take significant time to materialize. Patience and persistence will ensure that ITS ultimately makes its mark in improving transportation system efficiency."

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